Slant-Range Visibility

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LONG-TERM GOALS

The long-term goals of this three-year coupled rapid transition plan (RTP) 6.2-6.4 developmental effort is to transition products from the NRL Aerosol Analysis and Prediction System (NAAPS) to a database where they can be extracted by Target Acquisition Weapons Software (TAWS). This will enable NAAPS data to be directly accessible to the warfighter for mission planning purposes, and will provide information in areas where no visibility information is available. This will also allow TAWS to become a forecasting tool. Goals include developing methods to produce aerosol parameters, and incorporating these parameters into the Tactical Environmental Data Server (TEDS). The need exists to develop a general interface to extract slant path parameters from TEDS and to convert current radiative post-processor codes (extinction, optical depth, visibility) to use the TEDS database for input. TAWS must be modified to utilize these new parameters in TEDS. “Multiple level” TAWS experiments and verification with the new input (multi-level extinction coefficients, and scattering phase function description) are also required. Finally the TAWS/NAAPS performance vs. the existing TAWS will be documented and validated against observations to quantify the improvement.

OBJECTIVES

The objective is to incorporate the higher spatially and temporally resolved aerosol/optical parameters from NAAPS into TEDS for use by the TAWS in the computation of slant range visibility. This capability is intended to meet one of the longest-standing Fleet METOC requirements for the purpose of improving sensor performance prediction in support of Strike, Air-defense, and Infrared Search and Track (IRST).

APPROACH

The problem of slant path detection in the visible, near-IR and IR wavelengths will be addressed by incorporating the three-dimensional datasets of aerosol and optical parameters from NAAPS and cloud parameters from the Navy Operational Global Atmospheric Prediction System (NOGAPS) or the

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14. ABSTRACT
The long-term goals of this three-year coupled rapid transition plan (RTP) 6.2-6.4 developmental effort is to transition products from the NRL Aerosol Analysis and Prediction System (NAAPS) to a database where they can be extracted by Target Acquisition Weapons Software (TAWS). This will enable NAAPS data to be directly accessible to the warfighter for mission planning purposes, and will provide information in areas where no visibility information is available. This will also allow TAWS to become a forecasting tool. Goals include developing methods to produce aerosol parameters, and incorporating these parameters into the Tactical Environmental Data Server (TEDS). The need exists to develop a general interface to extract slant path parameters from TEDS and to convert current radiative post-processor codes (extinction, optical depth, visibility) to use the TEDS database for input. TAWS must be modified to utilize these new parameters in TEDS. ?Multiple level? TAWS experiments and verification with the new input (multi-level extinction coefficients, and scattering phase function description) are also required. Finally the TAWS/NAAPS performance vs. the existing TAWS will be documented and validated against observations to quantify the improvement.

15. SUBJECT TERMS

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Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS®[1]) into TEDS for use by TAWS. NAAPS is a tropospheric aerosol model used to generate near real-time, global forecasts. It uses meteorological fields from NOGAPS to generate dust, sulfate, and smoke forecasts at 6-hour intervals out to 120 hours on a 1x1 degree horizontal grid with 25 vertical layers. The new capability of NAAPS to forecast aerosol information as a function of location, altitude and wavelength will be included, along with NOGAPS and COAMPS products, into TEDS. Hence, our approach is "top to bottom" in that we begin with deriving new model parameters, developing methods from their inclusion into an operational database, compose retrieval algorithms and incorporation into TAWS, and develop new radiative transfer code in TAWS to take advantage of these new parameters.

WORK COMPLETED

In previous years, three stand-alone transmission codes were acquired and implemented on NRL computers. These codes allow investigation of different issues facing TAWS' use of gridded model data in calculations of slant path visibility. The codes are MODTRAN (Moderate resolution Transmission), SGR (Sky to Ground Ratio) and FAROP (Forecast of Atmospheric and Optical Properties). This approach allows calculations of slant path visibility at any wavelength, the use of NOGAPS meteorological fields defined at all levels, and comparison with observational data.

To validate TAWS and the NAAPS visibility post-processor (FAROP) we utilized horizontal visibility data and AERONET sun photometer network to simulate top of atmosphere (TOA) slant path visibility. We compared TAWS extinction values (utilizing standard AFWA and original LOTRAN weather data sources) with extinction values derived with NAAPS and FAROP data, and to measured extinction and optical depth values from field campaigns and AERONET data.

RESULTS

The models have been compared objectively by using the contrast transmittance, a unitless measure of the transmission of the atmosphere that is independent of background. This approach isolates the calculation of the atmospheric component of the calculation of slant path visibility and eliminates the need for target and background properties definition. MODTRAN gives the most accurate results and is used as a standard, but is expensive. The other two methods make approximations and are less accurate, but are computationally efficient. Based on the comparisons and practical considerations, FAROP was chosen as the NAAPS post-processor to calculate the optical properties for use in TAWS. The calculated properties are the extinction, absorption, and phase parameter for three wavelength bands (visible, near IR, and IR) at each level, as well as total visible optical depth. NAAPS and FAROP produce, twice daily, five-day forecasts of the three-dimensional distribution of bulk optical properties for the entire globe as well as derived integral quantities, such as contrast transmittance.

The comparison of TAWS and TAWS/NAAPS is centered on the AERONET sun photometer sites in the validation study. A database of surface visibility measurements as well as both NAAPS and AERONET data for Navy relevant regions has been compiled (e.g., Southwest Asia, East Asia, Mediterranean, etc.) Weather data files for the United Arab Emirates United Aerosol Experiment (UAE[2]) field campaign in August and September 2004 have been re-created, including surface, upper atmosphere, and aerosol data. Currently, the corresponding TAWS extinction database is being generated. As previous research has shown NAAPS to correlate well with measured optical depth

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[1] COAMPS is a registered trademark of the Naval Research Laboratory.

from AERONET (e.g. Figure 1), we expect the inclusion of NAAPS data will result in improvement in TAWS extinction values, and therefore in forecast visibility.

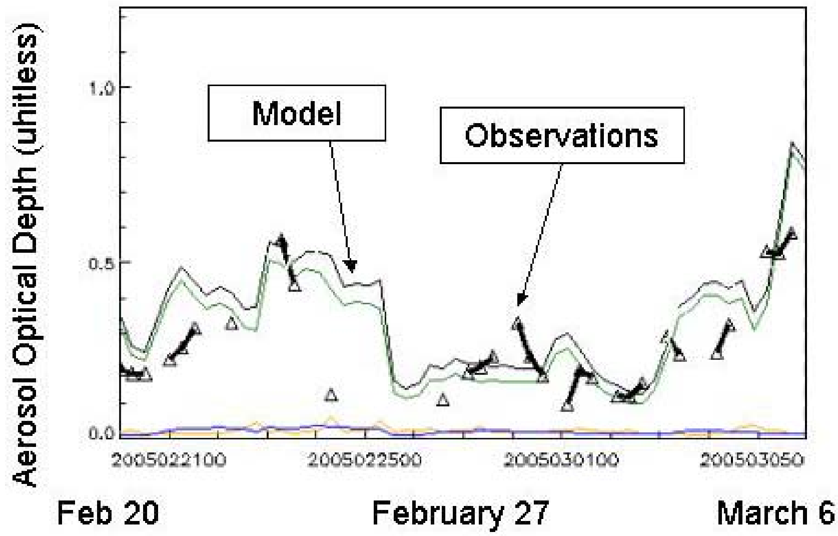

Figure 1. Time series of measured aerosol optical depth at Bahrain (triangles and thick lines) and NAAPS simulated aerosol optical depth (thin lines; black is total AOD for comparison with AERONET; green is dust, purple is smoke, and orange is sulfate) for February 20 – March 6, 2005. The plot shows that NAAPS accurately captures the timing and magnitude of several periods of high optical depth.

IMPACT/APPLICATIONS

TAWS is widely disseminated and utilized by many DoD commands for strategic, tactical and operational uses. The improvements made to the input to TAWS will directly impact these operations since NAAPS is a global model and therefore available in all theatres.

TRANSITIONS

The TAWS improvements and modifications from this work will be proposed for inclusion into the current baseline code by Northrop Grumman under contract to USAF ESC using previously established transition procedures. Operation of the new code will be evaluated and approved by the TAWS Change Control Board, at which time the program will be released for use by USA, USAF, USN, USMC, and USCG. USN distribution is through NITES II, GFMPL and approved CD distribution to OA divisions, METOC Detachments and USMC MAWTS-1 and MEW units.

PUBLICATIONS

2005, Westphal, D.L., Navy Aerosol Analysis and Prediction Systems, presented at the 2005 Weather Impacts Decision Aids (WIDA) Conference, Las Cruces, NM, on 1-3 March 2005.

2005, Westphal, D. L., A. Bucholtz, M. Liu, E. A. Reid, J. S. Reid, A. L. Walker, P. J. Flatau, C. A. Curtis, Operational Aerosol and Dust Storm Forecasting for DoD, to be presented at Battlespace

Atmospheric and Cloud Impacts on Military Operations (BACIMO) conference, Monterey, CA, October 12-14, 2005

RELATED PROJECTS

The NRL 6.1 base *Atmospheric Physics*, NRL 6.2 base *Improved COAMPS Land Boundary Layers* (includes COAMPS aerosol modeling) and NRL 6.2 *Advanced Moist Physics Modeling* use NAAPS data and products. The ONR 6.2 *Atmospheric Aerosol Characterization* will also use NAAPS simulations for high-energy laser research. The improvements to NAAPS and the implementation of NAAPS and FAROP at FNMOC are supported by PMW 180 6.4 *Large-scale and Mesoscale Aerosol Forecasting*. This project utilizes the products of the ONR 6.2 project *Aerosol Microphysics and Radiation*.